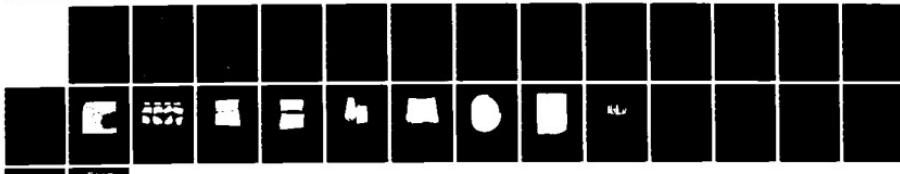


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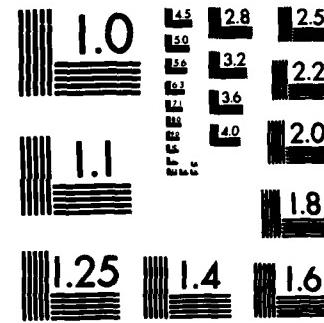
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Structures Technical Memorandum 381

LONG TERM DURABILITY OF UREA FORMALDEHYDE  
GLUED JOINTS REMOVED FROM VAMPIRE AIRCRAFT.

by

T. VAN BLARICUM and C. A. PATCHING

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LONG TERM DURABILITY OF UREA FORMALDEHYDE  
GLUED JOINTS REMOVED FROM VAMPIRE AIRCRAFT.

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T. VAN BLARICUM and C. A. PATCHING

SUMMARY

Bonded wooden specimens were removed from two Vampire aircraft fuselages and held in store for 18 years under ambient laboratory conditions to determine if glued-joint deterioration had occurred.

The examination did not reveal any significant deterioration.



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1. INTRODUCTION

Two Vampire fuselages A79/467 and A79/915 originally manufactured in 1950 were used for the A.R.L. Vampire Wing Fatigue Tests carried out between 1960 and 1965. (Ref. 1).

The Vampire fuselage is of laminated wooden monocoque construction utilising spruce, improved wood and aircraft plywood, bonded with Urea Formaldehyde (Beetle Cement) glue.

After completion of the wing fatigue tests a number of wooden specimens were removed from these fuselages and stored under ambient laboratory conditions until September 1983.

At the time of specimen removal, the fuselages A79/467 and A79/915 had been subjected to a total of 67,238 and 42,279 hours actual flying and simulated life.

Careful inspection of the fuselages before removal of the specimens revealed no indication of any defect indicating that design strength requirements were not being met. This report

This Technical Memorandum describes the condition of Urea Formaldehyde wooden joints from these specimens, broken open in September 1983. At this time the glue bonds had reached a life of 33 years. (10 p 4)

Examination of the condition of wooden joints from Vampire aircraft had been carried out by Hawker De Havilland Australia in May 1964. (Ref. 2). The results of those tests indicated that no significant deterioration in bond strength had occurred in joints with an age of 15 years.

2. TEST SPECIMENS

Test specimens were removed from three areas of the aircraft fuselage as shown in Fig. 1

(a) Drag or "C" Joint Attachment Area identified as:

Specimens A79/467 and A79/915 Port 1, Starboard 1.

(b) Air Intake Lower Forward Area identified as:

Specimens A79/467 and A79/915 Port 2, Starboard 2.

(c) Rear of Air Intake Area identified as:

Specimens A79/467 and A79/915 Port 3, Starboard 3.

Figure 2 is a general view of the twelve specimens.

### 3. TEST PROCEDURE

Part of each specimen was cut off and one or more of the following types of joint broken open by inserting a thin bladed chisel into the glue line:-

- (a) Laminated Spruce to Improved Wood.
- (b) Laminated Spruce to Plywood.
- (c) Spruce to Plywood.
- (d) Plywood to Plywood.
- (e) Plywood to Improved Wood.
- (f) Spruce to Improved Wood.
- (g) Spruce to Spruce.

Where possible joints which had been damaged during removal of the specimen from the aircraft were included in those selected for examination.

Each bond was examined using a magnifying glass and to ascertain the extent of wood failure as a percentage of the surface area of the joint.

A 100% effective joint is defined as having 100% wood failure and no apparent glue failure.

In some instances it was necessary to employ a strong light in order to detect the fine plywood fibres attached to the glue.

### 4. TEST RESULTS

Seven types of wooden joints bonded with Urea Formaldehyde glue were examined. Test results are given in Table 1. To enable a comparison of the different joints to be made the test results have been averaged as given in Table 2.

#### 4.1 Joint Failure

"Wood failure" was the predominant mode of failure for all joint types except in the case of Laminated Spruce to Improved Wood. The percentage wood failure refers to the percentage area of glued surface which is covered by wood fibres pulled from the mating timber surface.

#### 4.2 Performance of Individual Joint Types

##### 4.2.1 Laminated Spruce to Improved Wood

These joints had in most cases been damaged during removal of the specimens from the aircraft. Fig. 3 illustrates a typical example.

Note the Spruce fibres adhering to glue on the Improved Wood. The average amount of wood failure was 45% for 3 specimens.

#### 4.2.2 Laminated Spruce to Plywood

A few examples of this type of joint had been damaged during removal of the specimens from the aircraft. The remainder were in good condition and Figure 4 illustrates an example of a good Laminated Spruce to Plywood joint. Note Spruce fibres adhering to glue. The average of wood failure was 94% for 9 specimens.

#### 4.2.3 Spruce to Plywood

A few examples of this joint had suffered some slight mechanical damage during removal of the specimens from the aircraft. The remainder were in good condition. Fig. 5 illustrates a Spruce to Plywood bond. Note the plywood fibres adhering to the glue on the Spruce. The three examples of this joint all gave 100% wood failure.

#### 4.2.4 Plywood to Plywood

All examples of this joint were in good condition as illustrated in Fig. 6. Note plywood fibres adhering to glue. The average of wood failure was 97% for 4 specimens.

#### 4.2.5 Plywood to Improved Wood

Some examples of this joint had been slightly damaged during removal of the specimens from the aircraft. Fig. 7 illustrates one example with a thick glue line for over 40% of the joint area and no wood fibres detected on 30% of the joint area. The remaining undamaged bond area is covered in plywood fibres i.e. wood failure. The average of wood failure was 82% for 6 specimens.

#### 4.2.6 Spruce to Improved Wood

All joints examined were in good condition. Fig. 8, illustrates an example of a good Spruce to Improved Wood joint with 100% Spruce failure. The average of wood failure was 90% for 7 specimens.

#### 4.2.7 Spruce to Spruce

All five joints examined were in good condition and exhibited 100% wood failure. Fig. 9 illustrates a typical example.

### 5. DISCUSSION OF RESULTS

The test results indicated that the physical appearance of a bond line, for example apparent lack of glue does not correlate with its mode of failure. Joints with a poor external appearance still gave a high percentage of wood failure.

Every joint tested required considerable effort to prize it open with the chisel, indicating that the actual glue line was providing adhesion to both surfaces.

6. CONCLUSION

The report concludes that the long term exposure (18 years) of these wooden specimens to an ambient laboratory environment had not led to any significant deterioration of the Urea Formaldehyde bonded joints, and that after 33 years since manufacture the joints were still satisfactory.

REFERENCES

1. BRUTON R.A. and PATCHING C.A. Fatigue Testing of Vampire Wings. Department of Defence, Aeronautical Research Laboratories. Structures Report 378. June 1979.
2. Estimated Life of the Vampire Trainer Fuselage Wooden Structure in Service. Hawker De Havilland Australia Pty Ltd.

TABLE 1 - TEST RESULTS

TYPE OF JOINT: LAMINATED SPRUCE TO IMPROVED WOOD		
SPECIMEN IDENTIFICATION	PERCENTAGE WOOD FAILURE	COMMENTS
A79/467 Port 3	45%	Mechanical Damage, glue failure, thick glue line
A79/915 Port 3	50%	Mechanical Damage, glue failure, thick glue line
A79/915 Starboard 3	40%	Mechanical damage, glue failure
TYPE OF JOINT: LAMINATED SPRUCE TO PLYWOOD		
A79/467 Starboard 2	90%	Initial Appearance:- Joint in good condition
A79/915 Starboard 2	100%	Initial Appearance:- Mechanical damage. Failure showed a thick glue line
A79/467 Port 3	95%	Initial Appearance:- Joint in good condition
A79/467 Port 3	95%	Initial Appearance:- Joint in good condition
A79/467 Starboard 3	80%	Initial Appearance:- Mechanical damage
A79/467 Starboard 3	100%	Initial Appearance:- Joint in good condition
A79/467 Starboard 3	95%	Initial Appearance:- Joint in good condition

(2)

SPECIMEN IDENTIFICATION	PERCENTAGE WOOD FAILURE	COMMENTS
A79/915 Port 3	95%	Initial Appearance:- Mechanical damage
A79/915 Starboard 3	100%	Initial Appearance:- Mechanical damage
<b>TYPE OF JOINT: SPRUCE TO PLYWOOD</b>		
A79/467 Port 1	100%	Initial Appearance:- Joint in good condition
A79/467 Port 1	100%	Initial Appearance:- Joint in good condition
A79/915 Port 2	100%	Initial Appearance:- Mechanical damage. Failure revealed a thick glue line.
<b>TYPE OF JOINT: PLYWOOD TO PLYWOOD</b>		
A79/467 Port 2	100%	Initial Appearance: Joint in good condition
A79/467 Starboard 2	100%	Initial Appearance: Joint in good condition
A79/915 Port 3	90%	Initial Appearance: Joint in good condition
A79/915 Starboard 3	100%	Initial Appearance: Joint in good condition

(5)

TYPE OF JOINT: PLYWOOD TO IMPROVED WOOD			
SPECIMEN IDENTIFICATION	PERCENTAGE WOOD FAILURE	COMMENTS	
A79/467 Starboard 1	100%	Initial Appearance:- Apparent lack of glue, Joint in good condition.	
A79/467 Starboard 1	70%	Initial Appearance:- Joint in good condition	
A79/915 Port 1	100%	Initial Appearance:- Apparent lack of glue, Joint in good condition.	
A79/915 Port 1	90%	Initial Appearance:- Slight mechanical damage.	
A79/915 Starboard 1	40%	Initial Appearance:- Apparent lack of glue, Joint in good condition. Failure indicated that 60% of area not glued.	
A79/915 Starboard 1	90%	Initial Appearance:- Apparent lack of glue, Joint in good condition. Failure indicated that 10% of area not glued.	
TYPE OF JOINT: SPRUCE TO IMPROVED WOOD			
A79/467 Starboard 1	100%	Initial Appearance:- Joint in good condition	
A79/915 Port 1	50%	Initial Appearance:- Joint in good condition	
A79/915 Starboard 1	100%	Initial Appearance:- Joint in good condition	
A79/915 Starboard 1	100%	Initial Appearance:- Joint in good condition	

(4)

SPECIMEN IDENTIFICATION	PERCENTAGE WOOD FAILURE	COMMENTS
A79/467 Port 2	100%	Initial Appearance:- Slight Mechanical damage
A79/915 Port 2	80%	Initial Appearance:- Slight mechanical damage
A79/915 Starboard 2	100%	Initial Appearance:- Joint in good condition
TYPE OF JOINT: SPRUCE TO SPRUCE		
A79/915 Port 3	100%	Initial Appearance:- Joint in good condition
A79/915 Starboard 3	100%	Initial Appearance:- Joint in good condition
A79/467 Starboard 3	100%	Initial Appearance:- Joint in good condition
A79/915 Starboard 2	100%	Initial Appearance:- Joint in good condition
A79/467 Starboard 2	100%	Initial Appearance:- Joint in good condition

TABLE 2 AVERAGED TEST RESULTS

TYPE OF BONDED JOINT	AVERAGE %	NUMBER OF SPECIMENS
LAMINATED SPRUCE TO IMPROVED WOOD	45%	3
LAMINATED SPRUCE TO PLYWOOD	94%	9
SPRUCE TO PLYWOOD	100%	3
PLYWOOD TO PLYWOOD	97%	4
PLYWOOD TO IMPROVED WOOD	82%	6
SPRUCE TO IMPROVED WOOD	90%	7
SPRUCE TO SPRUCE	100%	5

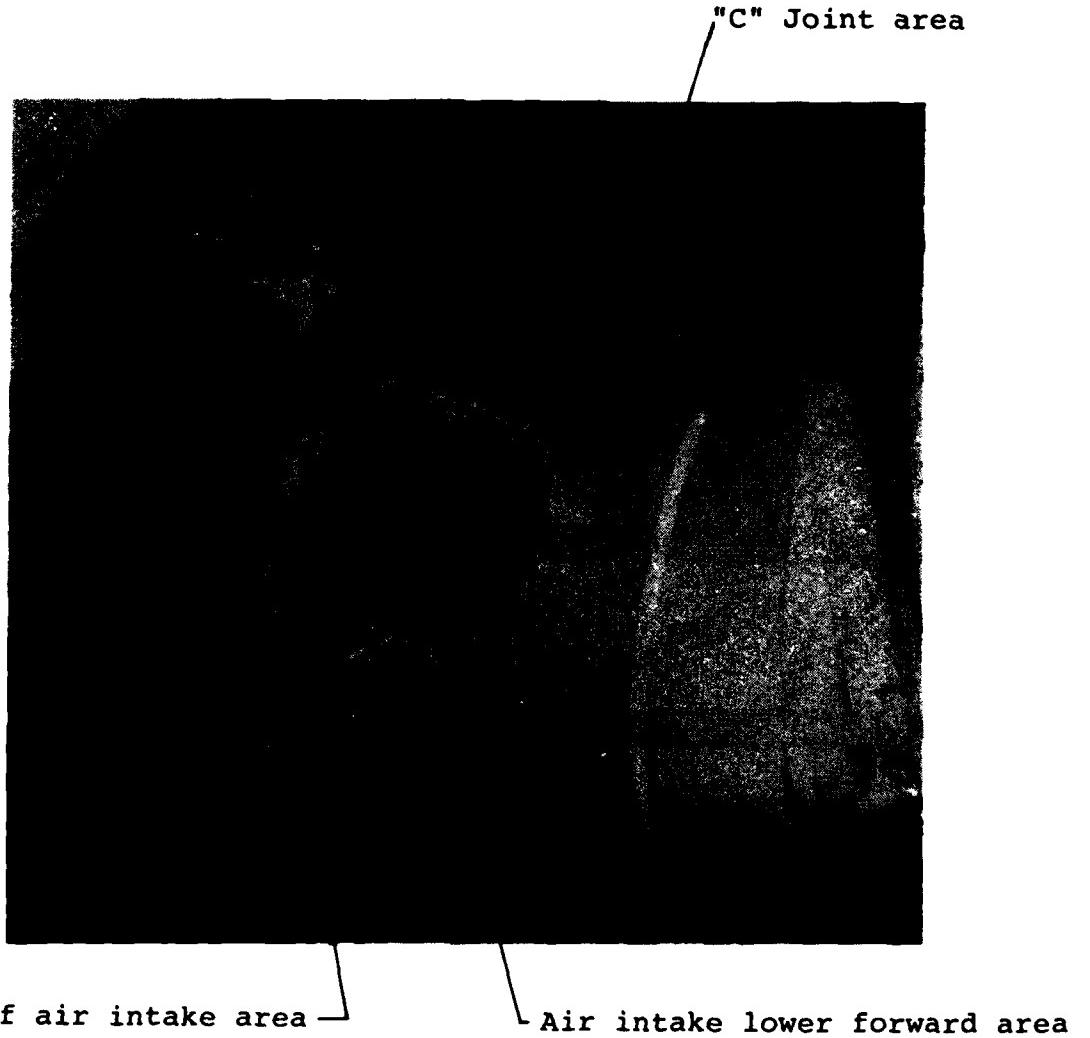
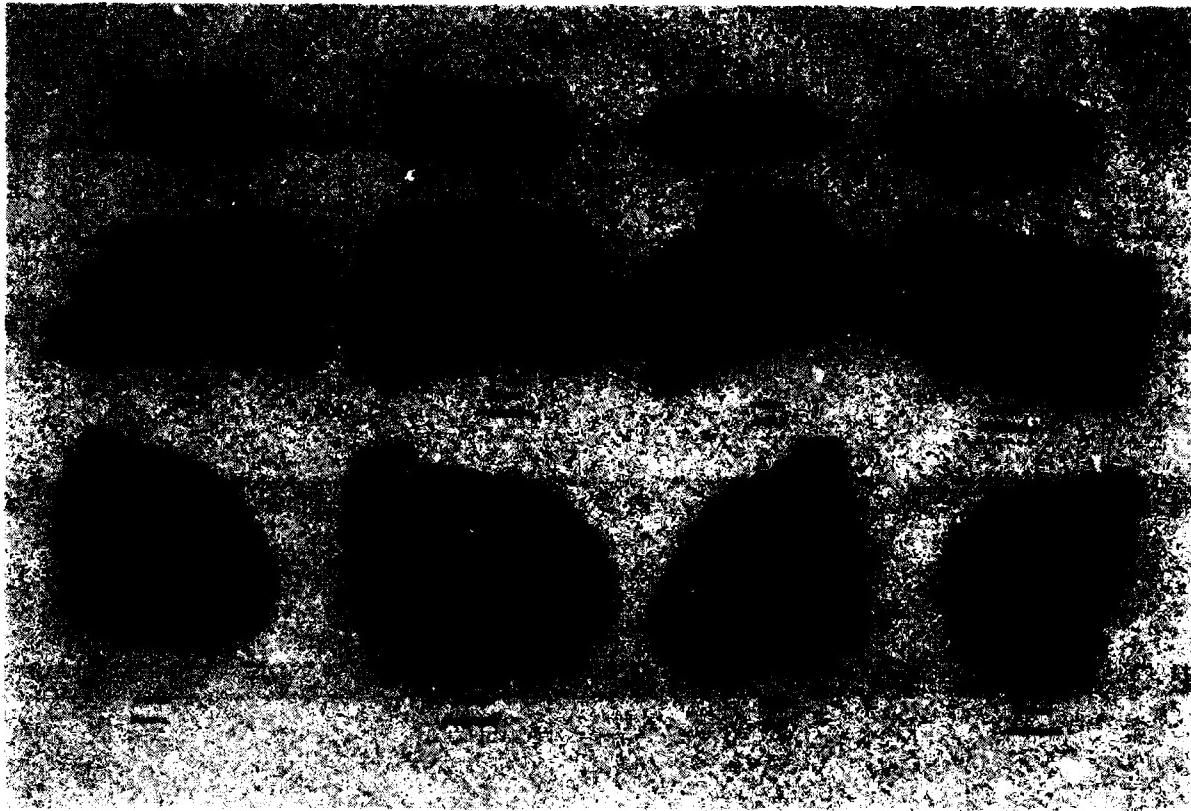


FIG. 1 SHOWING AREAS OF FUSELAGE FROM WHICH WOODED SPECIMENS WERE REMOVED.



**FIG. 2 GENERAL VIEW OF TEST SPECIMENS**  
**(Scale: Specimen labels are 110 mm X 60 mm)**

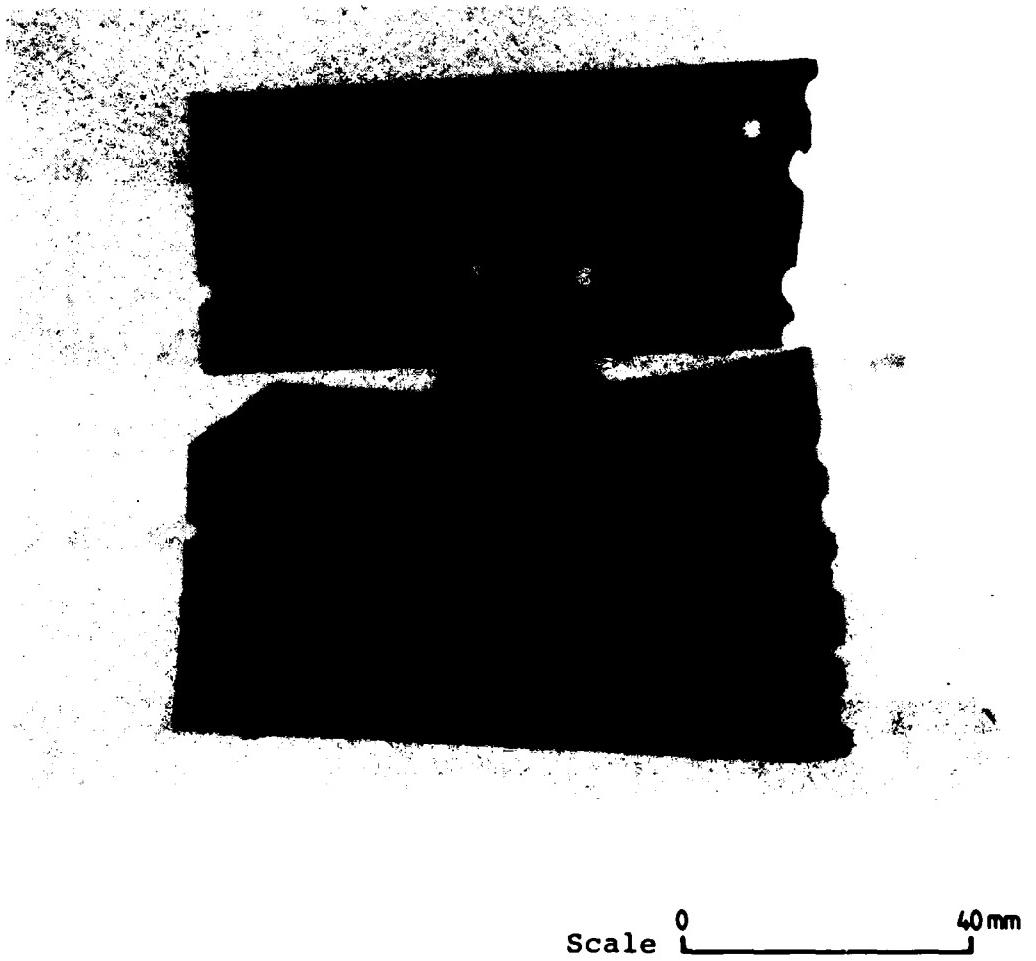
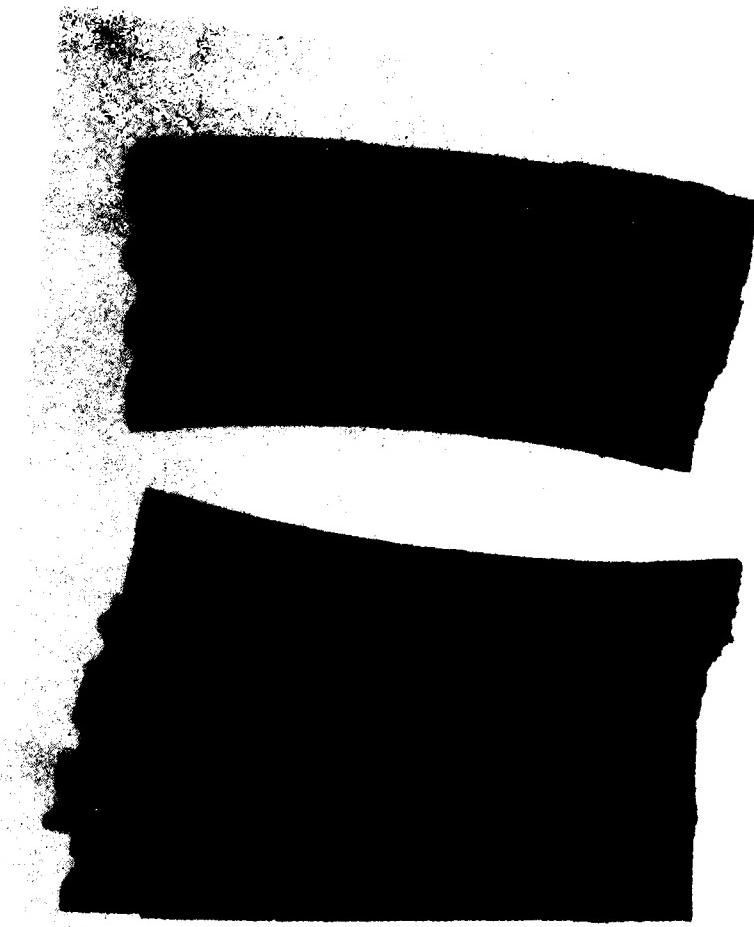


FIG. 3 SPRUCE TO IMPROVED WOOD NOTE THICK GLUE LINE  
AND SPRUCE FIBRES ON IMPROVED WOOD (A79/915 PORT 3)



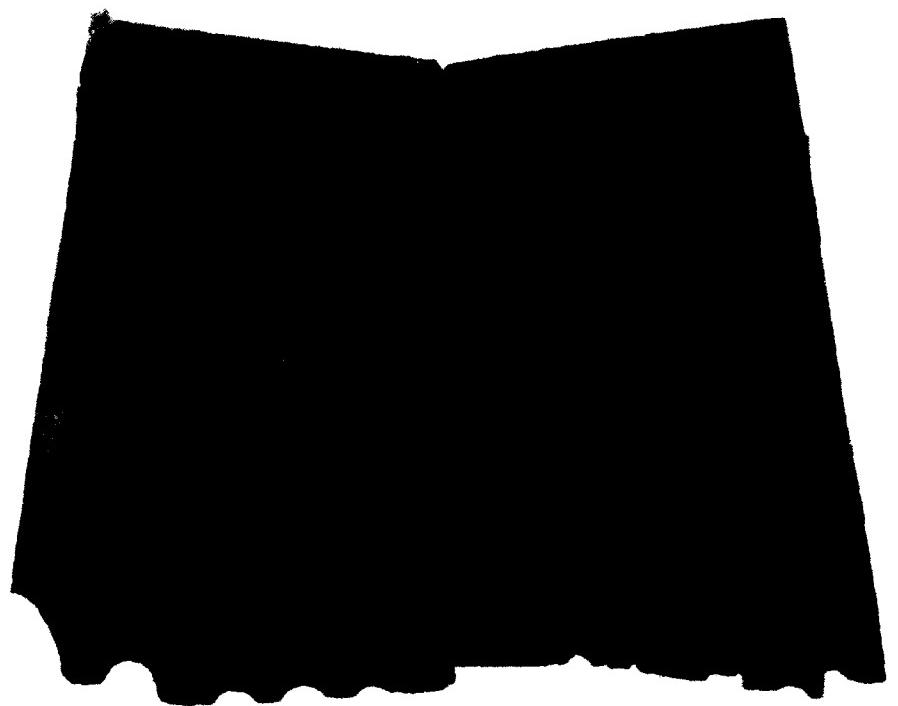
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FIG. 4 LAMINATED SPRUCE TO PLYWOOD  
NOTE HIGH PERCENTAGE WOOD FAILURE (A97/915 PORT 3)



Scale 0 40 mm

**FIG. 5 SPRUCE TO PLYWOOD JOINT  
NOTE PLYWOOD FIBRES ON GLUE (A79/467 PORT 1)**



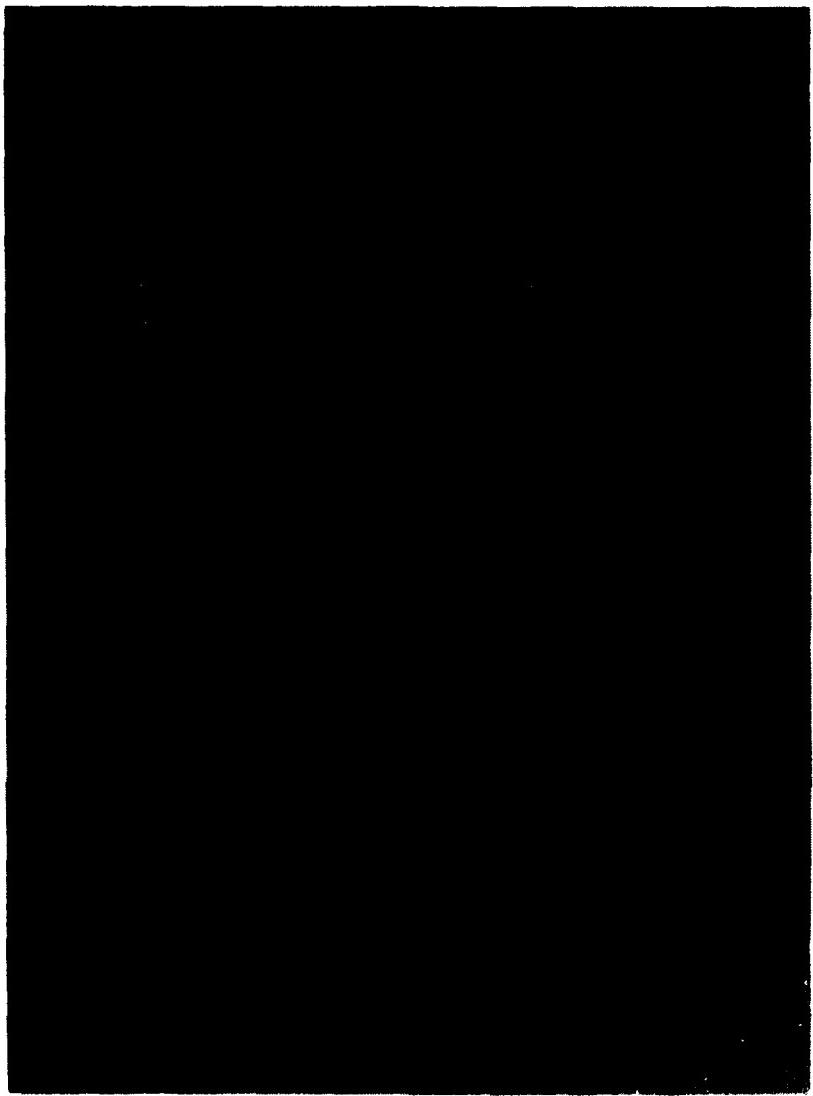
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FIG. 6 TYPICAL PLYWOOD TO PLYWOOD JOINT FAILURE (A79/915 PORT 3)



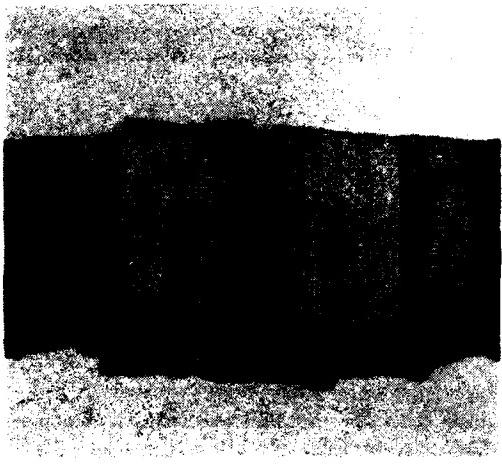
Scale 0      40 mm

**FIG. 7 AIRCRAFT PLYWOOD TO IMPROVED WOOD  
NOTE THICK GLUE LINE, PLYWOOD FIBRES  
ADHERING TO GLUE AND GLUE FAILURE  
(A79/467 STARBOARD 1)**



Scale 0 40 mm

FIG. 8 EXAMPLE OF A GOOD SPRUCE TO IMPROVED WOOD  
FAILURE IE 100% WOOD FAILURE (A79/467 STARBOARD 1)



Scale 0 40 mm

FIG. 9 A GOOD SPRUCE TO SPRUCE JOINT A79/467 STARBOARD 2

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